Endoprosthesis (EN) in a frontlim-sparing surgery for distal radial tumours in the dog: Preliminary results

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Abstract: In veterinary medicine, limb-sparing techniques are most implemented when the uninvolved limbs are affected by other orthopaedic or neurological disorders, in large breeds or when the owner declines amputation. This report describes the surgical technique used for implantation of an endoprosthesis following tumour resection in the distal radius in 3 dogs using both standard and angle-stable plates. Endoprosthesis offers an easy and readily available surgical alternative to cortical allografts. Despite post-operative complications, this technique resulted in a good quality of life in all 3 dogs.

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Introduction

Osteosarcoma (OSA) is the most common primary bone tumour in dogs, occurring frequently in middle-aged, large-breed dogs in distal radial metaphysis (Dernell et al., 2000). Fibrosarcoma is less common, representing approximately 5% of primary bone tumours in dogs and is difficult to differentiate histologically from fibroblastic OSA (Lui et al., 1977; Wesselhoeft et al., 1991). A common clinical presentation is painful swelling of the distal radius accompanied by varying degrees of lameness. Diagnosis is based on characteristic bony changes on radiographs and confirmed by histopathological examination of biopsies of the affected bone. Amputation of the affected limb in conjunction with adjuvant chemotherapy is generally performed in dogs, in contrast to human medicine, where limb-sparing techniques are considered the first line of treatment. However, limb sparing is indicated for dogs that will not be ambulatory after amputation because of concomitant orthopaedic or neurological disease, in very large breeds or for dogs whose owners refuse amputation (Dernell et al., 2000; Liptak et al., 2004). Using this technique in the distal radius, the most favourable results have been obtained with concurrent panarthrodesis of the carpal joint (Rovesti et al., 2002; Liptak et al., 2004; Ehrhart 2005; Liptak et al 2005).
This report describes the surgical procedure and outcome in 3 dogs with limb-sparing surgery for distal radial bone tumours using an EN with standard and angle-stable bone plates.

Animals, Material and Methods

Animals and preoperative evaluation

Three dogs were presented for evaluation of forelimb lameness. Preoperative evaluation included clinical examination, radiographs of the affected limb in 2 projections, thoracic radiographs in 3 projections and routine preoperative blood work in all dogs.

Case 1 was a 7 year-old, intact male Leonberger (69.2 kg) presented for progressive lameness of 10 days duration. The dog presented with moderate to severe lameness (grade IV of V) in the right forelimb and a painful swelling of the distal radius. Radiographs of the affected limb revealed proliferative changes and lysis of the radial metaphyseal cortex with an irregular periosteal reaction in the distal radius. Case 2 was a 9 year-old, intact female Great Dane (67.4 kg) referred with progressive intermittent lameness of 21 days duration and a

suspicion of OSA. The dog presented with moderate to severe lameness (grade IV of V) in the left forelimb and pain on digital compression of the distal radius. Radiographs of the limb revealed a moth-eaten lytic appearance of the distal radial metaphysis with cortical destruction and palisading periosteal bone formation. Case 3 was an 8 year-old, spayed female Rottweiler (48 kg) presented with acute lameness of 7 days duration. The dog presented with moderate to severe lameness (grade IV of V) in the left forelimb and a painful swelling of the distal radius. Radiographs revealed an irregular medullary bone density and areas of cortical lysis.

Routine preoperative blood work and thoracic radiographs were unremarkable in all 3 dogs. A diagnosis of OSA was based on cytology of fine-needle aspiration preparations and histopathology of multiple bone biopsies in Case 1. Cytology of fine-needle aspiration preparations of the affected bone revealed a poorly differentiated sarcoma in Case 2. Cytology of fine-needle aspiration preparations was inconclusive in Case 3 and the owner declined preoperative biopsy. In 2 dogs (Cases 1 and 2), limb-sparing surgery was offered because the owners refused limb amputation. In Case 3, limb-sparing surgery was considered indicated because of concomitant degenerative joint disease in the hips and elbows.

Surgical technique

The dogs were sedated with acepromazine (0.03 mg/kg IV) and buprenorphine (0.007 mg/kg IV). Anaesthesia was induced with propofol (6 mg/kg IV). The dogs were intubated and anaesthesia was maintained with isoflurane in 100% oxygen. After an initial aseptic skin preparation, a brachial plexus block was performed with 0.5% bupivacaine (1 mg/kg). Perioperative analgesia was provided with a continuous rate infusion of fentanyl (0.1ml/kg/h).

The dogs were positioned in dorsal recumbency. An adhesive antimicrobial incise drape (Ioban 2; 3M Health Care, Neuss, Germany) was placed over the aseptically prepared limb. An incision was made from the lateral proximal end of the radius, to the dorsal limb aspect at the level of the metacarpophalangeal joints. The deep fascia was incised between the common digital extensor muscle and the extensor carpi radialis. The tendons of the extensor carpi radialis muscle was transsected at the insertion on the third metacarpal bone. The distal radial tumour was resected en bloc to the radial carpal bone with all contiguous soft tissue structures. As the ulna was not affected in any of the dogs, this was left intact. The proximal radial osteotomy was determined by the length of the EN spacer used.

All EN implants were commercially-available veterinary implants (Veterinary Orthopedic Implants, Burlington, VT). The EN spacers used were 316L steel implants,

consisting of a 122-mm (Radius Plate A) in Case 1 or a 98-mm (Radius Plate B) long segment Cases 2 and 3, corresponding to the size of the resected bone segment. In all 3 cases, bone marrow was harvested from the proximal radial osteotomy site for histopathological examination. The joint surface of the radial carpal bone was flatened with an oscillating saw to ensure good fit with the EN spacer, bridging the resected bone. The EN spacer was then attached to the dedicated limb-sparing bone plate (Veterinary Orthopedic Implants, Burlington, VT). This plate has a larger profile than a standard 3.5-mm or 4.5-mm dynamic compression plate and the screw holes are round, increasing plate stability. To avert implant failure, the plate was not pre-bent, as is often performed for carpal arthrodeses, and all screw holes were filled (Piermattei et Flo, 1997; Lesser, 2003). In Cases 1 and 2, a standard limb-sparing bone plate was used (Limb Salvage Plate, 11.5 18SP, Veterinary Orthopedic Implants, Burlington, VT). In Case 3, an angle-stable plate was used with locking screw holes (Locking Limb Salvage Plate, 11.5 18SP LOC, Veterinary Orthopedic Implants, Burlington, VT). The plate with the spacer was fixed to the radius with 3.5-mm bicortical screws, to the radial carpal bone with 3.5-mm or 2.7-mm bicortical screws and to the third metacarpal bone with 2.7-mm bicortical screws using AO/ASIF techniques (Koch, 2005) (figure 1 and 2).
Prior to wound closure, a closed silicon drain (Blake® Style Fluted Drain, Ethicon, Spreitenbach, Switzerland) was placed alongside the plate. The wound was lavaged and a swab was harvested for bacterial culture. The fascia was closed using interrupted cruciate sutures, the subcutis and skin were closed routinely with simple interrupted sutures.

Postoperative treatment

A modified Robert Jones bandage was placed for 14 days with one bandage change after 1 day, to control the wound and to remove the drain and 1 at 7 days. Owners were advised to restrict the dogs' activities to a minimum of short leash walks. Postoperative antibiotics given to all 3 dogs consisted of cefazolin (20 mg/kg q12h PO) for 4 weeks. Postoperative pain management consisted of buprenorphine (0.007 mg/kg q6h IV) for 2 days, a transdermal fentanyl patch (Durogesic 100µm, Jannsen-Cilag, Baar, Switzerland) for 1 week, and carprofen (4 PO q24h) for 3 weeks.
Three weeks after surgery, systemic chemotherapy was initiated based on the histopathological results consisting of carboplatin (33 mg/m^2) given 4 times at an interval of 21 days (Cases 1 and 2) or doxorubicin (28 mg/m^2), given 5 times at an interval of 21 days (Case 3).

Results

Total surgical time was reduced from 3 hours in Case 1, to 2 hours in Cases 2 and below 2 hours in Case 3. The drain was removed after 24 hours in all 3 dogs because no further wound fluid was produced. Chemotherapy was well tolerated and lead to no serious complications in all 3 cases. Histopathological examination of bone harvested from the proximal radial osteotomy site revealed no evidence of tumour in any of the dogs. Histopathological examination of the resected radial tumour revealed OSA in Cases 1 and 2, and an intraosseous fibrosarcoma in Case 3.

Case1:

Despite an initial improvement in the degree of lameness during the first few days after surgery in Case 1, lameness worsened 2 weeks after surgery and a seroma developed over the proximal radius. Radiographs and cytological evaluation as well as bacterial culture of approximately 40 ml of fluid aspirated from the seroma revealed no evidence of infection or cancer cells. Four weeks after surgery, the lameness was evaluated as grade III of V and the carpal joint was considered swollen and painful on palpation. Radiographs revealed evidence of osteomyelitis in the proximal radius, loosening of 2 of the proximal screws, as well as some lysis and periostal new bone formation around the proximal end of the spacer. The owner declined any further surgical intervention. The dog was treated with clindamycin (11 mg/kg PO q12h) for 6 weeks, which lead to improvement of the degree of lameness and swelling after the first week. Six weeks after surgery, lameness was evaluated as grade II of V and the owner was satisfied with the outcome of surgery. However, 8 months after surgery, lameness worsened again and the dog was presented to the referring veterinarian with ulcerative lick dermatitis over the area covering the EN. Radiographs taken at this time revealed evidence of increased osteomyelitis in the proximal radius, loosening of the proximal screws in the radius, the radial carpal bone and the most proximal screw in the metacarpal bone (figure 3). The angle of the 3 most distal screws in the proximal radius had changed by 6° in a distal direction relative to the plate, indicating failure with proximal displacement of the implant. The ulcerative lick dermatitis was treated with wet-dry bandages for 2 weeks and cefazolin (20 mg/kg q12h PO) for 6 weeks, leading to improvement of lameness, which remained stable until 14 months after surgery. At this time, the dog died suddenly and post-mortem examination revealed rupture of a cardiac haemangiosarcoma.

Case 2:

In Case 2, the dog was using the limb 1 day after surgery and lameness improved to a grade II of V within 1 week of surgery. Two weeks after surgery, the paw became swollen. This

swelling subsided after removal of the bandage. Three and 9 weeks, as well as 3 months after surgery, lameness remained a grade II of V and a mild swelling of the carpal area was noted but the owner was satisfied with the outcome of surgery. Radiographs performed 9 weeks after surgery revealed loosening of 1 screw in the proximal radius and 1 screw in the metacarpal bone, as well as minimal bone resorption at the proximal and distal end of the spacer. Screws were not replaced. Five months postoperatively, bone resorption was most evident at the distal end of the spacer and the angle of the screw in the carpal bone and the proximal screws in the metacarpal bone had moved by 8° to proximal direction relative to the plate, indicating implant collapse with distal displacement of the spacer and plate. Six months postoperatively, radiographs revealed tumour recurrence in the distal ulna (figure 4) although no radiographic evidence of distant metastases was found. Histopathological examination of a bone biopsy of the lytic ulna confirmed the diagnosis of osteosarcoma and the dog was euthanized at the owner's request.

Case 3:

In Case 3, the dog was using the limb 3 days after surgery and lameness was considered grade II of V 2 weeks after surgery. Due to the development of acral lick dermatitis on the operated limb, a bandage and Elizabethan collar were applied for 3 weeks. Despite this, the owner was pleased with the outcome of surgery. Four months postoperatively, progressive lameness (grade III of V) was noted. Radiographs taken at this time revealed lysis surrounding 3 proximal screws in the radius, the screw in the radial carpal bone and 4 of 6 screws in the third metacarpal bone (figure 5). However, only minimal bone resorption was evident at the proximal and distal ends of the spacer. At this time, no radiographic evidence of local tumour recurrence or distant pulmonary metastasis was found. However, the owner declined further surgical treatment for the loosened screws and the dog was euthanized 5 months after surgery at the referring veterinarian because lameness worsened.

Discussion

The 3 dogs in this report were typical of dogs previously reported with appendicular osteosarcoma, being older, large-breed dogs with distal radial metaphyseal tumours (Dernell et al., 2000). Radiographic findings were consistent with previously described changes (Straw et al., 1991). Recently, use of a commercial endoprothesis (EN) has been described as an easy and readily available alternative to CA (Liptak et al., 2006).

In the 3 dogs in this study, good limb function was likewise achieved for 6 months in two dogs and for 4 months in the third.

Collapse of the implants in Case 1 can be explained by loosening of the proximal screws and bone resorption at the proximal end of the spacer. Loosening of proximal screws was likely promoted by their placement into the ulna, causing tension on the screws during pronation and supination. As the plate was not angle stable, the spacer collapsed with proximal displacement. Osteomyelitis was observed in Case 1, in this case the operation time was substantially longer than for the subsequent cases due to surgeon inexperience. Also one possible reason for the relatively high infection rate with EN is the large implant volume with a relatively small soft tissue covering over the distal radius, which may restrict local perfusion (LaRue et al., 1989; Kirpensteijn et al., 1998; Kuntz et al., 1998; Morello et al., 2001; Lacelles et al., 2005). An infection rate of 50% with EN, similar to that of CA, was previously reported (Liptak et al., 2006). In Case 2, the distal screws loosened and bone resorption occurred in the radial carpal bone. In this case, the spacer collapsed with distal displacement. In Case 3, an angle-stable plate was used, there was little bone resorption at the ends of the spacer and no change in the angle of the screws, which are fixed in the plate. However, larger areas of lysis were observed around the proximal and distal screws, leading to significant resorption of the radius and radial carpal bone with subsequent collapse and distal displacement of the implant over time.

Implant failures with EN consist mostly in loosening of the proximal screws in the radius or in fractures of the distal screw hole in the third metacarpal bone (Liptak et al., 2006). For this reason, it is recommended that 80% of the metacarpal bone is covered by the limb-sparing plate and that the plate should not be pre-bent when arthrodesis is performed following tumour removal (Liptak et al., 2006). In the cases presented herein, screw loosening was detected in one dog 6 months after surgery, which may possibly have been prevented by using an angle-stable plate as was used in Case 3. This type of plate carries further advantages because it does not need to be placed directly on bone, which averts time-consuming pre-bending of the plate and compromises the blood supply under the plate to a lesser degree. As the greatest stress on EN constructs is at the junction between the EN and bone (Liptak et al., 2006), the shortest possible EN should be chosen to minimise lever-arm forces (Liptak et al., 2006). Beside the larger volume, the longer EN used in Case 1 may be in part responsible for complications observed in this dog. Thus far, a revision rate of 20% following reconstruction with EN in dogs is similar to that observed with other limb-sparing techniques (Liptak et al., 2006). Further improvement of success with EN might be achieved with newer hydroxyapatite-coated ENs that may compensate osseous integration. This could improve the transmission of forces and diminish the concentration of stresses between the EN and bone

(Lord et al., 1988; Karabatsos et al., 2001). In addition, an innovative device used in human medicine (Compress® implant, Biomet, Warsaw) has been developed to enable massive endoprosthetic fixation through the application of compressive forces at the bone-implant interface. This design provides immediate stable anchorage and helps to avoid the long-term complication of aseptic loosening secondary to stress shielding and particle-induced osteolysis.

This device is presently not available for veterinary application but holds potential to avert implant failure as seen in our cases.

The ulna was not affected in any of the 3 dogs, but 1 dog developed local recurrence consistent with previous reports of only 4% of cases with ulnar involvement (Straw et al., 1991). Resection of the ulna, even if no initial radiographic evidence of involvement is observed, might therefore be considered to improve outcome. Moderate dose radiation in combination with chemotherapy and surgery may, however, be useful for control of local disease, but wound healing may be complicated and the risk of infection may be potentiated (Zachos et al., 1999).

Distant metastases were not detected in the dogs in the present report. Postoperative infection is known to increase the risk of implant failure (Liptak et al., 2004) but can increase survival in dogs with OSA (Lacelles et al., 2005; Thrall et al., 1990). Chemotherapy may cause myelosuppression and increase the risk of infection (Chun et al., 2001). A modified Robert-Jones bandage was applied for 2 weeks postoperatively to prevent tissue swelling and seroma development. This was considered necessary because the lymphatic drainage can be compromised after resection of the radial bone and attached soft tissues, which may enhance local fluid accumulation and reduce local immune defences (Fox et al., 2000).

Conclusion

The advantage of EN over other limb-sparing techniques is the relatively simple surgical technique without the need for bone-banking facilities. The 3 cases reported herein demonstrate that EN is a relatively acceptable alternative to CA for dogs with distal radial tumours. Implant failure may be reduced by using the shortest possible EN and angle-stable plates. The infection rate is higher than in other orthopedics procedures because of the large implant volume, small soft tissue covering and the development of instability over weeks. The complication rate with EN is higher than with a limb amputation. Limb-sparing surgery with EN should be reserved for patients with concurrent neurological or orthopaedic conditions or when the owner refuses amputation.

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Legends for figures:

figure 1:

Intraoperative situation in case 2. Dorsolateral approach to the bone tumore in the distal radius. The tumor was resected and the endoprosthesis spacer and dedicated limb-sparing bone plate was fixed to the radius and the third metacarpal bone.

figure 2:

Postoperative lateral radiograph of limb-sparing surgery using an EN with a 98mm long spacer. Distal aspect of the radius of case 2.

figure 3:

Lateral radiograph of limb-sparing surgery in case 1. Construct failure eight months postoperativly with limb-salvage using endoprosthesis, involved screw loosening in the proximal aspect of the radius, the radial carpal bone and the proximal screw in the metacarpal bone. Bone resorption is evident at the proximal and distal ends of the spacer. Evidence of increased osteomyelitis in the proximal radius.

figure 4:

Lateral radiograph of limb-sparing surgery 6 month postoperativly in case 2. Evidence of soft tissue swelling, bone resorption at the distal end of the spacer and tumor recurrence in the distal ulna.

figure 5:

Lateral radiograph of limb-sparing surgery, 4 months postoperativly in case 3, with angle-stable plate and locking screws. The radiographs reveal lysis surrounding, the 3 most proximal screws in the radius, the screw in the radial carpal bone and the most distal screws in the third metacarpal bone. Minimal bone resorption at the proximal and the distal ends of the spacer are visible.

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